Dec. 28, 1954 L. J. PATLA 2,698,372

ELECTRICAL RESISTOR AND METHOD OF MAKING SAME

Filed April 23, 1951 3 Sheets-Sheet 1

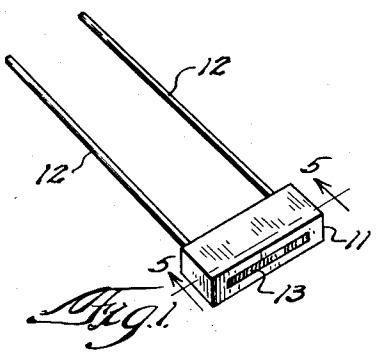


Fig. 1.

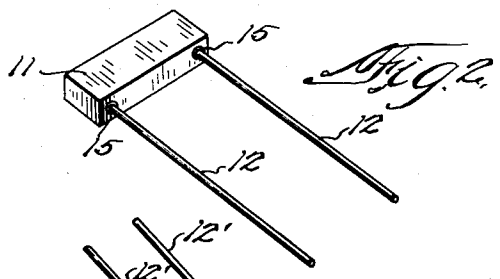


Fig. 2.

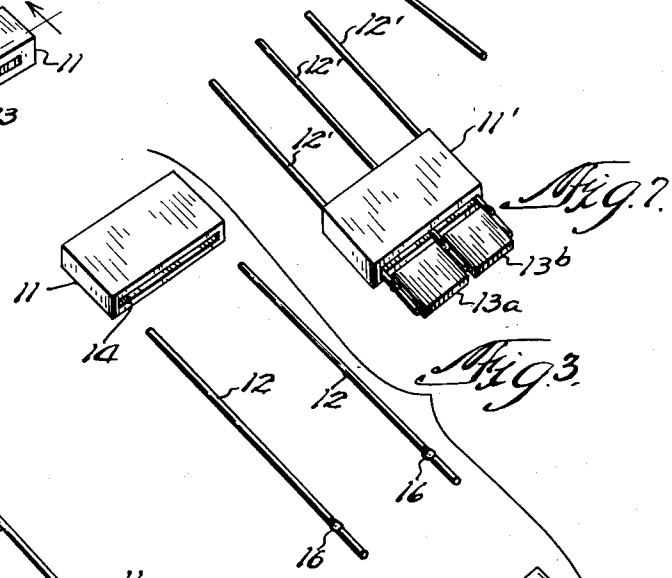


Fig. 7.

Fig. 3.

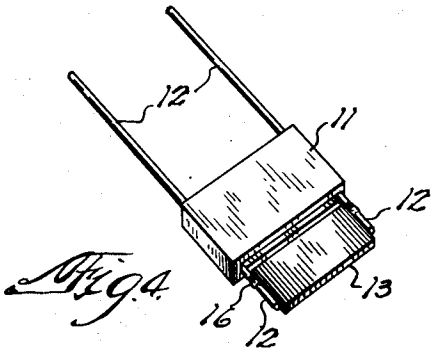


Fig. 4.

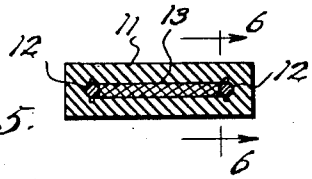


Fig. 5.

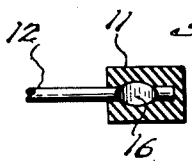


Fig. 6.

INVENTOR.
Louis J. Patla.
BY
Thies, Albaugh & Mackelburger.
Attys.

Dec. 28, 1954 L. J. PATLA 2,698,372

ELECTRICAL RESISTOR AND METHOD OF MAKING SAME

Filed April 23, 1951 3 Sheets-Sheet 2

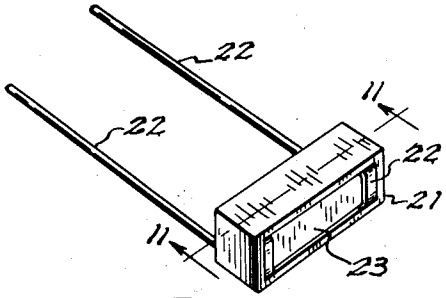


Fig. 8.

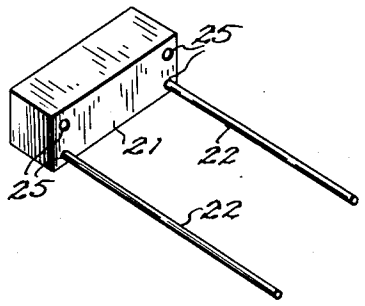


Fig. 9.

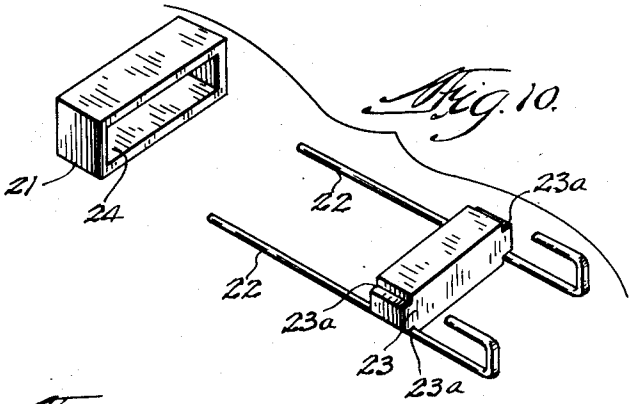


Fig. 10.

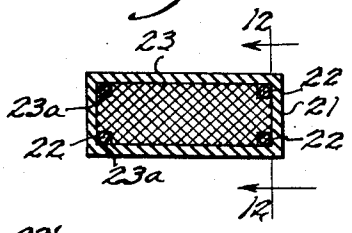


Fig. 11.

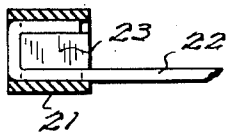


Fig. 12.

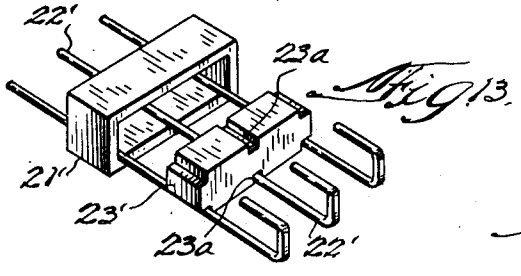


Fig. 13.

INVENTOR.
Louis J. Patla.
BY.
Thies, Olbar & Mecklenburger.
Attys.

Dec. 28, 1954 L. J. PATLA 2,698,372

ELECTRICAL RESISTOR AND METHOD OF MAKING SAME

Filed April 23, 1951 3 Sheets-Sheet 3

Fig. 14.

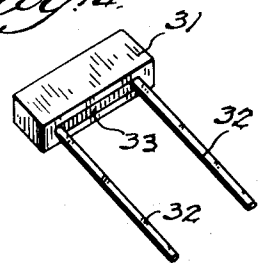


Fig. 15.

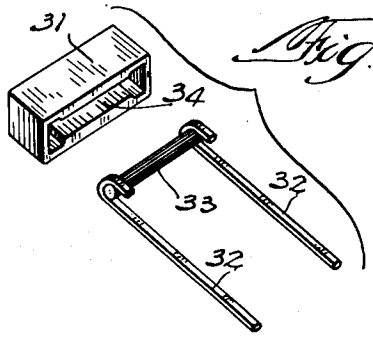


Fig. 16.

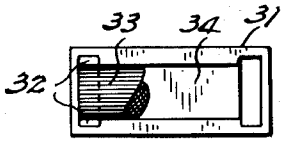


Fig. 17.

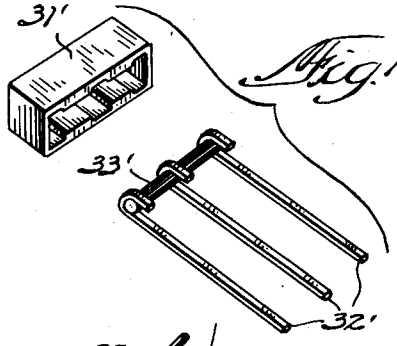


Fig. 18.

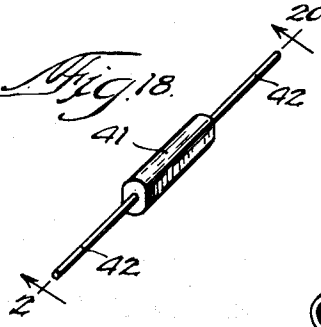
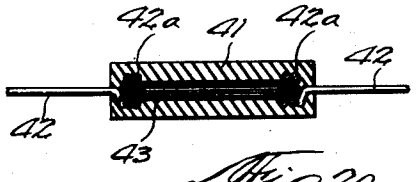


Fig. 19.

Fig. 20.



INVENTOR.
Louis J. Patla.
BY.
Thew, Obar & Mecklenburg.
Attys.

United States Patent Office

2,698,372

Patented Dec. 28, 1954

2,698,372

ELECTRICAL RESISTOR AND METHOD OF MAKING SAME

Louis J. Patla, Elmwood Park, Ill.

Application April 23, 1951, Serial No. 222,353

7 Claims. (Cl. 201—67)

This invention relates to an electrical resistor and a method of producing resistors. It is an object of the invention to provide an improved electrical resistor and an improved method of manufacturing resistors.

Resistors constructed in accordance with one embodiment of the invention are wholly or almost entirely insulated during the construction of the resistor, the insulation forming a part of the structure of the resistor body. Also, the resistor although almost entirely insulated is readily alterable as to its resistance value by a substantial amount after completion.

The method of producing resistors which constitutes one feature of the invention is simple and rapid and lends itself readily to mass production of completely or partially insulated resistors of improved quality. In accordance with one embodiment of the invention a resistance element or material and one end of each of two or more resistor leads are arranged in a pre-formed shell of moldable insulating material. The assembly is then subjected to pressure and preferably its temperature elevated to mold the assembly into an integral body.

It is another object of the invention to provide an improved method for constructing insulated resistors.

It is another object of the invention to provide an improved method for constructing insulated resistors by which method the various elements of the resistor, namely, the leads, the resistance element and the insulation are molded into a unitary body.

It is another object of the invention to provide an improved method of producing insulated or partially insulated resistors in which the insulation, the resistance element or material and the leads are readily assembled.

It is another object of the invention to provide an improved electrical resistor having all but one surface thereof insulated.

It is another object of the invention to provide an improved electrical resistor which is completely insulated with the exception of the central area of one substantially flat surface.

It is another object of the invention to provide an improved electrical resistor whose resistance value is readily alterable after completion although it is insulated on all but one surface or a portion thereof.

It is another object of the invention to provide an improved electrical resistor having an improved and simplified arrangement for providing substantially uniform current distribution over the entire cross section of the resistance element.

It is another object of the invention to provide an improved electrical resistor having the characteristics described above while being durable, reliable and economical to manufacture.

It is another object of the invention to provide an improved method for producing electrical resistors having the characteristics described above.

This invention, together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the drawings, in which like parts are designated by like reference numerals,

Fig. 1 is a perspective view of a resistor constructed in accordance with one embodiment of the invention;

Fig. 2 is a similar perspective view of the same resistor taken from a different angle;

Fig. 3 is an exploded perspective view of the same resistor;

Fig. 4 is a perspective view of the same resistor showing the various elements thereof partially assembled;

Fig. 5 is an enlarged cross-sectional view taken along the line **5—5** of Fig. 1;

Fig. 6 is a cross-sectional view taken along the line **6—6** of Fig. 5;

Fig. 7 is a perspective view of a partially assembled resistor construction similar to that shown in Figs. 1 through 6 but having a center tap;

Fig. 8 is a perspective view of a resistor constructed in accordance with another embodiment of the invention;

Fig. 9 is a perspective view of the same resistor illustrated in Fig. 8 but taken from a different angle;

Fig. 10 is an exploded perspective view of the resistor illustrated in Figs. 8 and 9;

Fig. 11 is an enlarged cross-sectional view of the same resistor taken along the line **11—11** of Fig. 8;

Fig. 12 is a cross-sectional view of the same resistor taken along the line **12—12** of Fig. 11;

Fig. 13 is an exploded perspective view of a resistor construction similar to that disclosed in Figs. 8 through 12 but having a center tap.

Fig. 14 is a perspective view of a resistor constructed in accordance with another embodiment of the invention;

Fig. 15 is an exploded view of the resistor illustrated in Fig. 14;

Fig. 16 is a front elevational view of portions of the resistor illustrated in Figs. 14 and 15;

Fig. 17 is an exploded perspective view of a resistor construction similar to that illustrated in Figs. 14–16 but having a center tap;

Fig. 18 is a perspective view of a resistor constructed in accordance with another embodiment of the invention;

Fig. 19 is an exploded view of the resistor illustrated in Fig. 18; and

Fig. 20 is a cross-sectional view taken along the line **20—20** of Fig. 18.

The resistors shown in the drawings are so-called fixed resistors, that is resistors which are not variable at will. However, the resistance value of a completed resistor constructed in accordance with some of the illustrated embodiments of the invention may readily be permanently increased, as for example in the event that the completed resistor is found to have a resistance value somewhat lower than is desired.

The resistor shown in the Figs. 1 to 6 includes a boxlike body member **11** of insulating material, a pair of leads **12**, and a block or sheet of resistance material **13**. The body member **11** is preferably a rectangular parallelepiped in form and is boxlike or hollow, with at least one side **14** thereof at least partially open to receive the two leads **12** and the block of resistance material **13**. In this particular embodiment of the invention the body member **11** also has a pair of openings **15** which open into the box adjacent the ends thereof and opposite the open side **14**. The openings **15** are of such size as to receive the respective resistor leads **12**, and when the leads extend through these openings they lie along the ends of the cavity within the body member as is best illustrated in Fig. 4.

With the leads **12** in place, there remains just sufficient space in the body member **11** to receive the resistance block **13** snugly. If desired the resistance block may be inserted into the body member at the same time as the leads.

It will be noted best in Figs. 3 and 6 that the leads **12** are, in the illustrated embodiment, swaged or otherwise distorted near the ends which ultimately engage the ends of the resistance block **13**. The distortion produces a flattened spot **16** having a substantially increased diameter in one direction. The flat spot **16** may be used to advantage in the assembly of the various components of the resistor since the increased diameter thereof may be relied upon to determine the respective assembled positions of the leads **12** and the body member **11**. The holes **15** may, for example, be made of such size as to freely receive the leads but to prevent the passage therethrough of the flattened spots **16**. Accordingly, if the body member **11** is held in a position wherein the openings **15** are at the bottom, the leads may be dropped into the holes **15** and will come to rest in a position wherein the flat-

tened spots 16 engage the bottom wall of the body member. The flat spots also serve to anchor the leads firmly in position upon completion of the resistor as will subsequently become apparent.

The body member 11 is preferably constructed of a naturally occurring or synthetic plastic which is either thermosetting or thermoplastic in character. The resistance element 13, also, is preferably a thermoplastic or thermosetting plastic made conducting by inclusion therein of particles of conducting material such as carbon.

With the various elements of the resistor so constructed, and arranged as illustrated in Fig. 1, the assembly may be formed into an integral body by the application of heat and pressure, the elevated temperature causing the body member 11 and the resistance element 13 to become plastic with the result that the applied pressure causes these elements to flow and form a substantially solid body, with the leads 12 firmly embedded therein. It will be apparent that the material forming the body member 11 and the material forming the resistance block 13 will flow around the leads 12 during the molding operation with the result that the irregularities in the contour of the leads at the flat spots 16 will cause the leads to be securely bound within the body of the resistor.

It has been suggested above that the body member 11 and the resistance element be formed of a plastic. It is within the scope of the invention, however, that these parts be of any material which permits the retention of a predetermined shape or form during assembly and which lends itself to subsequent integration of the assembly into a unit. The retention of shape by the body member 11 during assembly is particularly advantageous as this permits convenient assembly of the various resistor parts, the body member retaining the resistor element and the leads in the desired relationship.

In accordance with the embodiment of the invention illustrated in Figs. 1–6, and as will be noted by reference to Fig. 1, one edge of the resistance block 13 remains exposed, after the assembly and integration operations. Accordingly, it is possible to remove a portion of the material comprising the resistance element, as by scraping the exposed surface with a knife, whereby the resistance value of the resistor may be increased by any reasonable amount as may be desired. However, the resistance element is exposed only at the center of the corresponding surface of the completed resistor, that is, the resistance element does not extend to any of the four edges of that surface of the completed resistor. Accordingly, the small exposed surface is quite well protected against accidental contact with another conducting element. The result, then, is a resistor which is almost entirely insulated but which may, nevertheless, be readily altered as to its resistance value, even after completion.

In this connection, it will be noted that the exposed edge of the resistance block 13 extends parallel to the direction of current flow through the resistance block. Accordingly, the removal of any of the material from the exposed edge of the resistance element reduces the cross section of the element through which current may pass, and increases the resistance value proportionately.

In the resistor disclosed in Figs. 1–6, the leads 12 extend substantially across the entire width of the resistance element 13 thereby conducting current to substantially all points along each end of the resistance element. This eliminates local hot spots and thereby increases the permissable power rating of the resistor since it effects substantially uniform current distribution throughout the entire length of the resistance element. Uniform current distribution is desirable for the further reason that the resistance value is more readily predetermined.

If desired, it is possible to insulate the surface of the resistor at which the edge of the resistance element is exposed. For example, after the resistor has been completed and its resistance value checked, and, if necessary, increased in the manner previously described, the edge of the resistor assembly having the exposed edge of the resistance block may be dipped into an insulating varnish or otherwise covered with any suitable insulative coating. Furthermore, where it is not essential that one edge surface of the resistance element be exposed, the body 11 may be made sufficiently deep that the edges defining the opening 14 may flow over and insulate the otherwise exposed edge of the resistance element during the molding operation.

The invention lends itself readily to the incorporation of a center tap, as is illustrated in Fig. 7. In that figure it will be noted that the resistance element is in two parts, 13*a* and 13*b*. The body member 11′ has three openings, all similar to the openings 15 in Figs. 1 through 6, for receiving three leads 12′, the middle one of the leads constituting a center tap.

The resistor elements illustrated in Fig. 7 are assembled in substantially the same manner as those employed in the construction of the resistor illustrated in Figs. 1 through 6. After the resistor construction has been assembled, the body member, the resistor elements, and the leads are bonded by the application of heat and pressure to form an integral structure. The resultant resistor is substantially identical with that shown in Figs. 1 through 6 except that a center tap is provided for purposes well recognized in the art.

The embodiment of the invention disclosed in Figs. 8 through 12 is somewhat more complex than the embodiment so far described but has certain advantages thereover which will subsequently become apparent. In this embodiment of the invention there is provided a body member 21, a pair of leads 22 and a resistance element 23. The body member and the resistance element are preferably thermosetting or thermoplastic in character, or otherwise having the characteristics described above in connection with the embodiment of the invention illustrated in Figs. 1–6. The body member 21 is preferably a parallelepiped in form and is boxlike or hollow and has a large opening 24 through which the leads 22 and the resistance element 23 may be inserted. At the side of the body member opposite the opening 24, there are provided a plurality of openings 25 through which the leads 22 may extend.

The ends of the leads 22 which are to engage the ends of the resistance elements 23 are previously bent into a U-shaped formation of substantial depth and the corners of the resistance element are cut away to form notches 23*a* for receiving the leads 22. It will be noted by reference to Fig. 10 that at each end of the resistor element, a portion of the main body of a lead 22 may lie in one notch 23*a* while the opposed portion of the U-shaped formation may lie in the other of the two notches at that end.

In the assembly of the various parts of the resistor the resistance element 23 may be dropped through the opening 24 and into the boxlike body member 21 after which the free ends of the leads 22 may be inserted through the notches 23*a* and through the openings 25 until the U-shaped formations at the other end of the leads are arranged in opposed notches at the respective ends of the resistance element. The various elements of the resistor will then be in the position shown in Fig. 8. The various elements of the resistor may then be firmly bonded together into a single body.

In the embodiment of the invention disclosed in Figs. 8 through 12 each lead 22 contacts one end of the resistance element 23 along two lines, both of which extend across the entire depth of the resistance element. Excellent current distribution is thereby obtained even in those portions of the resistance element immediately adjacent the leads. This arrangement is particularly desirable where the resistance element is of substantial width. The U-shaped formation of the leads 22 at the resistor engaging ends thereof is also advantageous in that it provides a very strong mechanical bond between the leads and the plastic portions of the resistor. It will be apparent that it would be practically impossible to tear one of the leads 22 from the body of the resistor without first destroying the resistor.

In the interest of ease of assembly a pair of openings 25 previously described are provided at each end of the body element 21. With this arrangement the leads 22 may be inserted in either of the two notches 23*a* at the ends of the resistor during assembly, the holes 25 being aligned of course with respective notches 23*a*.

As in the case of the resistor illustrated in Figs. 1 through 6, the resistor just described is preferably so proportioned that one face of the resistance element 23 remains exposed after the molding process. Any desired amount of the resistance element may then be removed, as by scraping with a knife, in order to increase the resistance value if so desired. At the same time the entire body of the resistor is substantially insulated, particularly since the exposed surface of the resistance element is cen-

trally located, that is, it does not extend to the edges of the corresponding surface of the completed resistor.

This second embodiment of the invention is also well adapted to the installation of a center tap as is illustrated in Fig. 13. In that figure it will be noted that an additional pair of notches **23***a* are provided near the center of the resistance element **23**. These notches are adapted to receive a third lead **22'** which serves as a center tap. An additional pair of openings, similar to the openings **25** seen in Fig. 9 are provided at the center of the body member **21'** through either of which the middle lead **22'** may extend.

Another embodiment of the invention is disclosed in Figs. 14, 15 and 16. In this embodiment there is provided a body member **31**, a pair of leads **32** and a resistance element **33**. The body member **31** may be identical to the member **21** of Figs. 8–12 except that no openings for the leads are necessary in the wall thereof opposite the opening **34**.

The leads **32** may be of various forms but preferably are like those disclosed in Figs. 8–12. In this embodiment, the leads are inserted into the body member **31** in such a way as to extend outwardly thereof through the principal opening **34**. Where leads are employed having U-shaped ends the resistance element may be similar to that disclosed in Figs. 8–12 but is illustrated here as being cylindrical in form and of such diameter as to fit snugly within the U-shaped portions of the leads.

Preferably, and especially where a resistance element of uniform cross section is employed, the opening in the body member is enlarged at the two ends to receive the leads. In effect a groove is provided along three sides of the body member for receiving the U-shaped end of each lead, the grooves and the leads being so proportioned that after the leads have been inserted in the grooves there is provided a channel of substantially uniform cross section for receiving the resistance element. This arrangement, in addition to providing a better fit for the resistance element tends to support the leads in their proper positions such that the various portions of the resistor may readily be assembled and maintained in proper relative position prior to the molding operation.

The various resistor parts are preferably constructed of materials similar to those recommended in the description of the preceding embodiments such that the assembly may be molded into a single integral body by the application of heat and/or pressure.

As in the case of the previously described embodiments of the invention, the resistor construction illustrated in Figs. 14–16 lends itself readily to the inclusion of a center tap. In Fig. 17 there is illustrated an assembly incorporating such a center tap, the body member **31'** preferably having a third groove therein for receiving the center tap lead **32'**.

Still another embodiment of the invention is illustrated in Figs. 18, 19 and 20 in which an open ended body member **41** is provided which is preferably cylindrical in form. In the latter case a resistance element **43** is provided which is also cylindrical in form and so proportioned as to be insertable into the cylindrical opening in the body member **41**. Two leads **42** are provided, each of which terminates in a coil **42***a*, the coils receiving the respective ends of the resistance element **42** snugly.

In assembling this resistor the two leads may first be forced over the ends of the resistance element **43** and the entire subassembly then inserted into the body member **41**, or the resistance element may be inserted in the body member separately or with one lead connected thereto after which the other lead or leads may be forced into place over the ends of the resistance element within the body member. Preferably the ends of the resistance element and the coiled ends of the leads lie well within the body member **41** in order that the ends of the body member may be molded over and thereby insulate these parts. As in the case of the previously described embodiments, the body member and the resistance element are preferably formed primarily of a plastic which is either thermosetting or thermoplastic in character.

It will now be apparent that the particular embodiments of the invention disclosed in the drawings are very simple and durable resistors which are economical to manufacture, well insulated, and yet, in most instances at least, readily alterable to increase the resistance value if desired. Furthermore, very simple and practical means of distributing the current over the entire width of the resistance block are employed, along with means, namely the flattened lead portions **16**, the U-shaped lead ends, or the coiled lead ends, for facilitating manufacture and for assuring a firm mechanical bond between the resistor leads and the body of the resistor.

It has been suggested above that the resistance elements **13, 23, 33** and **43** be of a solid form at the time of assembly and that they be thermosetting or thermoplastic in character. It is within the scope of the invention that these resistance elements be fixed in size and shape at the time of assembly with only the corresponding body member being moldable. It is preferred, however, that the resistance element also be moldable in order to obtain a better electrical connection between the leads and the resistance element.

It is also within the scope of the invention that the various illustrated resistance elements be inserted into the respective body members in a fluid or semifluid condition. In such case the resistance elements might for example be of a plastic which is thermosetting or thermoplastic in character and be poured or packed into the corresponding body member at such an elevated temperature that it is in a fluid or semifluid condition.

Accordingly, while particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto since many modifications may be made, and it is, therefore, contemplated to cover by the appended claims any such modifications as fall within the true spirit and scope of the invention.

The invention having thus been described, what is claimed and desired to be secured by Letters Patent is:

1. An electric resistor comprising a boxlike member of insulating material, said member being a rectangular parallelepiped in form and open at one surface thereof, a resistance element in the form of a substantially solid block of resistance material secured therein, said element being of rectangular parallelepiped form and exposed at said one surface of said member, and three leads, one end of each of said leads extending through the wall of said boxlike member opposite said one surface and being secured within said member in electrical contact with said element along parallel spaced lines extending substantially across one dimension of said element, said one dimension being perpendicular to said exposed surface of said element.

2. An electric resistor comprising a boxlike member of insulating material, said member being a rectangular parallelepiped in form and open at one surface thereof, a resistance element in the form of a substantially solid block of resistance material secured therein, said element being exposed at said one surface of said member, and three leads, one end of each of which extends through said open surface of said member and being secured within said member in electrical contact with said element at spaced points.

3. The method of producing an electric resistor which comprises forming a U-shaped bend at one end of each of a pair of leads, forming four substantially parallel slots in a resistance element substantially a rectangular parallelepiped in form, arranging said resistance element and the U-shaped ends of said leads within a rectangular parallelepiped boxlike member of plastic insulating material having one side thereof open, with said leads extending outwardly of said body member and with opposed legs of said U-shaped lead ends lying in said slots in said resistance element, and subjecting the assembly to heat and pressure thereby converting the assembly into a bonded unitary structure with said leads electrically contacting said resistance element.

4. The method of producing an electric resistor which comprises forming a U-shaped bend at one end of each of a pair of leads, forming recesses at each of four parallel extending edges of a thermosetting resistance element substantially a rectangular parallelepiped in form, arranging said resistance element and the U-shaped ends of said leads within a rectangular parallelepiped boxlike member of thermosetting plastic insulating material having one side thereof open, with said leads extending outwardly of said body member and with opposed legs of said U-shaped lead ends lying in said recesses in said resistance element, and subjecting the assembly to heat and pressure thereby thermally setting the plastic materials and converting the assembly into a bonded unitary structure with said leads electrically contacting said resistance element.

5. The method of producing an electric resistor which

comprises arranging a plastic resistance element in the form of a substantially solid block of resistance material and the ends of three resistor leads within a boxlike member of plastic insulating material having one side thereof open, with said leads extending outwardly of said body member in spaced relationship and with said resistance element contacting said leads, and subjecting the assembly to heat and pressure thereby converting the assembly into a unitary structure with said leads electrically contacting said resistance element.

6. The method of producing an electric resistor which comprises forming a U-shaped bend at one end of each of three leads, forming six substantially parallel slots in a plastic resistance element substantially a rectangular parallelepiped in form, arranging said resistance element and the U-shaped ends of said leads within a rectangular parallelepiped boxlike member of plastic insulating material having one side thereof open, with said leads extending outwardly of said body member and with opposed legs of said U-shaped lead ends lying in said slots in said resistance element, and subjecting the assembly to heat and pressure thereby converting the assembly into a bonded unitary structure with said leads electrically contacting said resistance element.

7. The method of producing an electric resistor which comprises arranging a resistance element and one end of each of a pair of resistor leads in a rectangular parallelepiped boxlike member of insulating material having one side thereof open and having a pair of spaced openings in the side of said member opposite said open side thereof, with said leads extending respectively through said pair of openings and with said resistance element contacting said lead ends, and bonding the assembly into a unitary structure.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,167,868	Willis	Jan. 11, 1916
1,913,272	Graf	June 6, 1933
1,983,267	Browne et al.	Dec. 4, 1934
2,176,604	Benkelman	Oct. 17, 1939
2,282,328	Herrick et al.	May 12, 1942
2,282,398	Ehrlich	May 12, 1942
2,454,508	Herrick et al.	Nov. 23, 1948
2,479,557	Chanowitz	Aug. 23, 1949
2,506,482	Batcheller	May 2, 1950